

# Radioactive Source Training

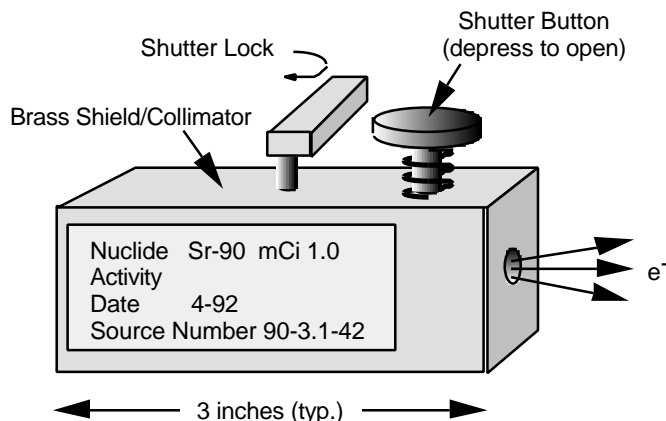
Fermilab's radioactive source program allows Fermilab to meet the needs of experiments, protect the health and safety of employees and experimenters, and assure compliance with DOE regulations. This training describes Fermilab's radioactive source control program, common configurations of sources used at Fermilab, review of ALARA concepts, source inventory number system, source monitor responsibilities, and source use policies.

## Identify three source configurations used at Fermilab.

### A. Common Configurations of Sources Used at Fermilab

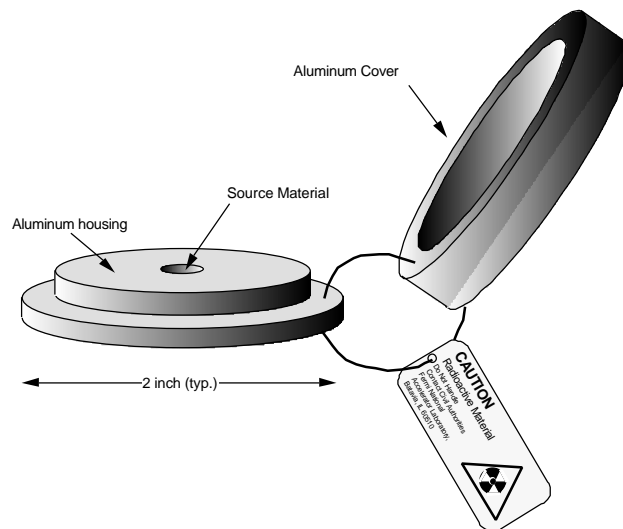
#### 1. Beta Gun Configuration

- Sr-90 or Ru-106 source installed in a brass holder.
- Beta gun has a shutter mechanism on the top of the gun. When the shutter is pushed down, it is open; betas come out the collimated opening at the front end.
- When the shutter is released, it is closed; betas are shielded.
- Bremsstrahlung radiation is produced from betas interacting with the brass holder.
- Some dose rates from beta guns cause Radiation Areas to exist. To determine if a Radiation Area exists, the dose rate is measured with the shutter open in the direct beam.



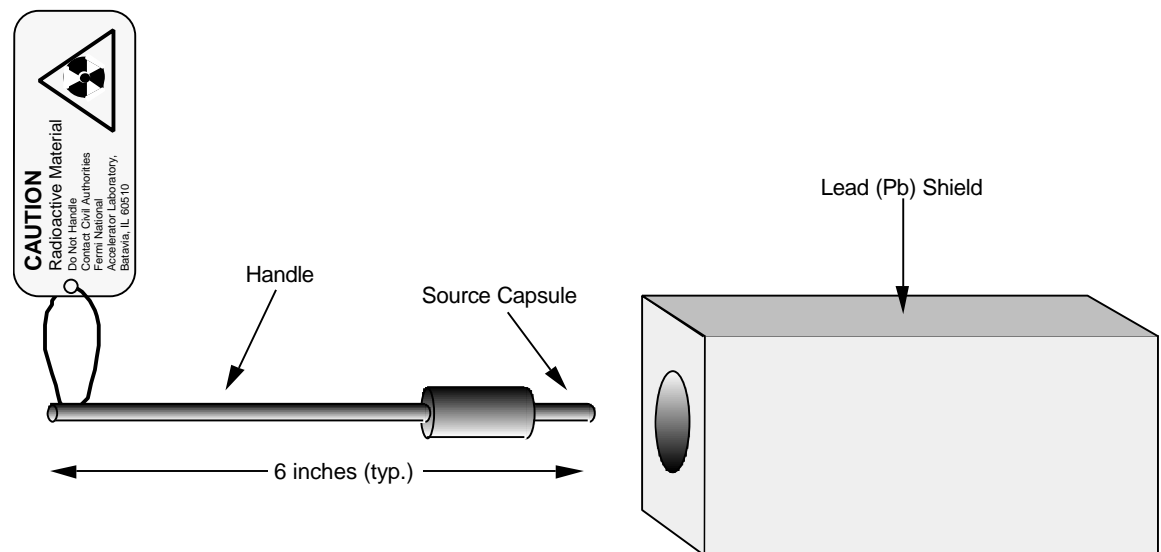
## 2. Disk Configuration

- Fe-55 and Sr-90 and Ru-106 are commonly housed in 2 inch diameter aluminum disks.
- There is a cover attached to the disk that should be used when the source is being stored.
- When putting the cover on the disk, do not crimp the wire that attaches the source ID tag to the disk. If you notice damage to the wire, please notify the source physicist or the source technician.



### 3. Wand Configuration

- Higher energy gamma emitters: Cs-137, Co-60 and Na-22.
- Delivered in a lead shielded container called a “pig”.
- Source should remain in lead shield during storage and transport to location of use.



## Review ALARA, radiation exposure reduction principles and units of radioactivity.

### B. ALARA and Methods of Radiation Dose Reduction

1. ALARA stands for As Low As Reasonably Achievable. It is a radiation safety principle for keeping radiation exposures as low as reasonable achievable.

Use time, distance and shielding to keep exposures ALARA.

Time: **Minimize** the time spent in the vicinity of a source.

Distance: **Maximize** the distance between you and a radioactive source. The inverse square law applies to point sources:  $1/r^2$  where  $r$  is the distance from the source. If distance is doubled between you and the source, the dose is reduced by a factor of four.

Shielding: **Maximize** shielding. Use appropriate shielding for the type of radiation emitted from the source. Aluminum or plastic can be used for beta radiation and lead or some other high-density material can be used for gamma or x-ray radiation.

2. Radioactivity is expressed in units of either Curie (Ci) or Becquerel (Bq). Fermilab uses units of curie or subunits such as millicurie ( $1 \times 10^{-3}$  Ci) and microcurie ( $1 \times 10^{-6}$  Ci).  
 $1 \text{ Curie} = 3.7 \times 10^{10}$  disintegrations per second (dps).  
 $1 \text{ millicurie} = 3.7 \times 10^7 \text{ dps}$   
 $1 \text{ microcurie} = 3.7 \times 10^4 \text{ dps}$   
  
 $1 \text{ Becquerel} = 1 \text{ dps}$

## Explain each part of the inventory number (source ID).

### C. Radioactive Source Inventory Number System

- Fermilab has a unique system of source identification. Upon arrival at Fermilab, the source technician assigns each source an individual inventory number (Source ID).
- The inventory number is the atomic mass followed by representation of the initial radioactivity (activity) in microcuries (rounded to one significant figure). The last number is a sequential serial number denoting the number of sources of that atomic mass and activity that are in the inventory to date.

Examples are as follows:

- (1) For the 51<sup>st</sup> 1000 microcurie <sup>90</sup>Sr source in the inventory:

$$\begin{array}{ccc} 90 & - & 3.1 & - & 51 & \leftarrow \text{source \# 51 in inventory} \\ \uparrow & & \uparrow & & & \\ \text{Atomic mass} & & 1 \times 10^3 = 1000 \text{ microcuries (initial activity)} & & & \end{array}$$

- (2) For the 1<sup>st</sup> 500 microcurie <sup>137</sup>Cs source in the inventory:

$$\begin{array}{ccc} 137 & - & 2.5 & - & 1 & \leftarrow \text{source \# 1 in inventory} \\ \uparrow & & \uparrow & & & \\ \text{Atomic mass} & & 5 \times 10^2 = 500 \text{ microcurie (initial activity)} & & & \end{array}$$

- (3) For the 9<sup>th</sup> 0.4 microcurie <sup>241</sup>Am source in the inventory:

$$\begin{array}{ccc} 241 & (-1.4) & 9 & \leftarrow \text{source \# 9 in inventory} \\ \uparrow & & \uparrow & & \\ \text{Atomic mass} & & 4 \times 10^{-1} = 0.4 \text{ microcurie (initial activity)} & & \end{array}$$

## **Identify Fermilab source monitor responsibilities and procedures for proper use of source lock keys.**

### **D. Fermilab Source Monitor Responsibilities**

1. Source monitors are assigned source lock keys for designated source storage box/cabinets.
2. If you are **not** a source monitor, you need to contact the source monitor designated for a particular box/cabinet to use a source. If a source monitor is not available when you need to use or return a source, notify the ES&H Section source physicist or source technician. You should ensure that a source monitor will be available at the time you return the source to storage.
3. Source monitors are responsible to:
  - Ensure that his/her name is posted near the source box.
  - Lock and unlock source storage boxes.
  - Complete the source access log sheet each time a source is removed and returned to the storage box.
  - Verify that the source user requesting a source is qualified to use sources. A current list of persons qualified to use sources is on the ES&H Section web page. The web address is [http://www-esh.fnal.gov/train/source\\_training.html](http://www-esh.fnal.gov/train/source_training.html)
  - Return source lock keys to the source physicist if he/she leaves Fermilab or for any reason, or no longer chooses to be designated as a monitor.
  - Ensure source users post a “Caution, Radioactive Material” and either “Caution, Controlled Area” or “Caution, Radiation Area” sign (as appropriate) during source use. These labels are usually kept in source storage boxes.

4. Keys to source box/cabinet locks should **not** be transferred to persons who are not source monitors. In some cases, source monitors may share a source lock key. For example, if a source lock key is kept in a key box with other keys, all source monitors for a particular source box may use the key.
5. Source lock keys shall **not** be duplicated. The source physicist coordinates duplication of keys.

<b>Identify Fermilab policies for proper and safe source use.</b>
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#### **E. General Source Use Policies**

1. To obtain a radioactive source that is not currently located in a source storage box, contact the source physicist (or designee). The source physicist will complete the radioactive source loan form and the user shall sign the form.
2. Sources with dose rates high enough to cause Radiation Areas to exist require specific written work authorization. This work approval requires signatures of authorized users and source monitors. The dose rate at one foot from the source is recorded and special precautions for source use are documented. Division/Section Head signature is required to authorize the use of this type of source.
3. A list of sources which cause Radiation Areas is posted either inside or in close proximity to each source box. The source user should refer to this list as a reminder to determine whether the source they are using causes a Radiation Area.
4. Requests for source installation or modification of source holders must be discussed with ES&H Section personnel.

5. Purchase requisitions for radioactive sources should be forwarded to the ES&H Section source physicist or designee for proper approval and signatures.
6. Sources and source boxes/cabinets shall be accessible to ES&H Section personnel for monthly inventory and leak testing.

## **F. Radioactive Source Controls**

1. Do not tamper with, disassemble or modify a source or its housing in any way.
2. Do not detach the "Caution Radioactive Material" label or the source identification tag from the source.
3. Immediately notify the ES&H Section source physicist or source technician if a source appears to be missing.
4. Call x3131 immediately if you suspect that a source is damaged in a way that could cause contamination. Do **not** handle or allow others to handle the source. If you think you may have radioactive contamination on your body or clothes, ask someone to dial x3131 and stay where you are.
5. Do not leave sources unattended. Sources shall be constantly attended or secured in a way that prevents unauthorized use.
  - If you leave for lunch, either return the source to its storage box or arrange for another qualified source user to oversee the source during your absence.
  - If you leave for a few minutes for a phone call or a break, you must either secure the source or have a qualified source user oversee the source.



- Contact the ES&H Section source physicist if a source needs to be in use for an extended period of time (several hours, days) without returning it to its storage box/cabinet. Special arrangements will be made to ensure that the source is secured in a way that prevents unauthorized use.
6. Keep radioactive sources in a locked box/cabinet when not in use. The storage box/cabinet shall be labeled "Caution Radioactive Material." Portable source storage containers are unacceptable.

## **G. Radioactive Source Posting Requirements**

1. Always display a "Caution Radioactive Material" sign near the source during use. Return this sign to source box/cabinet when source is no longer in use.
2. If the dose rate from a source does **NOT** cause a Radiation Area, then post all access points where the source is used and stored as follows:
  - (a) "Caution, Controlled Area"
  - (b) "Caution, Radioactive Material" or "Caution, Radioactive Material Area"

3. A Radiation Area exists when the dose rate is equal to or greater than 5 mR/hr at 30 cm (one foot) from the source.

If a source causes a **Radiation Area**, the user shall:

- Wear a TLD badge.

**Remember to wear TLD badge between your neck and waist. The TLD badge wear period is for 3 months at a time. Therefore, TLD badges must be exchanged every January 1<sup>st</sup> (or first working day after New Year's holiday), April 1st, July 1st, and October 1st. TLD badges shall not be taken off site.**

- Post all access points to the area where the source is used as follows:

(a) "Caution, Radiation Area"

(b) "Caution, Radioactive Material" or  
"Caution, Radioactive Material Area"

4. If the source will be used in an open area, ropes, chains or stanchions should be used to post each access point. When a source is returned to storage, these postings should be removed.
5. If the source is used inside a room, every door or the outside wall next to each door should be posted.
6. When sources are contained within experimental apparatus, a clearly visible "Caution Radioactive Material" label indicating the source ID shall be attached to the outside of the apparatus.

## **H. Radioactive Source Transfers**

### **1. On Site Transfers**

- The user shall contact the ES&H Section source physicist or source technician to arrange for on site source transfers. ES&H Section personnel deliver, pick up and transport sources in government vehicles. Transport of sources in private vehicles is prohibited.
- Contact the ES&H Section source physicist or source technician when the source is no longer needed. ES&H Section personnel will pick up the source and return it to ES&H Section storage.
- The user may carry sources on foot from one building to another as long as the source is returned to its designated storage box after use.

### **2. Off Site Transfers**

- Radioactive sources shall not be brought on or taken off Fermilab site unless approved in advance by Fermilab's Senior Radiation Safety Officer (SRSO) or designee. Fermilab's SRSO is the ES&H Section Head.
- To ship a source off site, contact the source physicist or source technician. A material move request form must be completed before the source can be shipped. The source technician will pick up the source, package it and take it to Shipping/Receiving.

## **I. Source Incidents**

- A technician punctured an Americium-241 source capsule. Damage to this source resulted in contamination in Wilson Hall and in the individual's house. It also resulted in an internal radiation dose to the individual.
- Several Iron-55 foil sources were destroyed because the foil was torn away from the source. A worker was instructed to remove layers of aluminum foil that had been used to shield the sources. Because the surface of the source is also foil, the worker was unaware that he was tearing the source material. This incident resulted in contamination on the worker and the workbench.
- A Cobalt-60 wand source capsule was removed from the aluminum handle and was never found. An Iron-55 source was removed from its aluminum disk holder and never recovered.
- Workers were cleaning an area and piled scrap and junk on top of a wooden box. During a safety walk through, it was noticed that the box was marked as containing radioactive material. Further investigation showed that there was a Ruthenium-106 radioactive source installed the box. The source was removed to prevent it from being tossed out with the rest of the scrap.
- There have been recent instances where radiological signs have not been posted properly.
- A 5 millicurie Strontium-90 source was left in a pedestal drawer of a workbench instead of being returned to the source storage box.
- A Cesium-137 wand source was damaged because it was mistakenly placed in a scanner that was not designed for this source.
- A Ru-106 disk source was removed from experimental apparatus and left in an unsecured location instead of being returned to the source box.

If violations of source control policies occur, sources are confiscated and returned to ES&H Section storage. In general, Division/Section Head approval is required before the sources may be reissued.

If source use policy violations occur, the user's source use privileges may be revoked.

## J. Radioactive Source Reference Information

Nuclide	Half-life	Principal Radiations	gEnergy, or Maximum b Energy (MeV)	Range of Activities
$^{55}\text{Fe}$	2.7 yr.	$\gamma$	0.006 (Mn X-ray)	0.07 $\mu\text{Ci}$ to 10 mCi
$^{60}\text{Co}$	5.27 yr.	$\gamma$	1.17, 1.33	0.003 $\mu\text{Ci}$ to 2 mCi
$^{137}\text{Cs}$	30.2 yr.	$\gamma$	0.662	0.03 $\mu\text{Ci}$ to 2 mCi
$^{22}\text{Na}$	2.60 yr.	$\gamma$	0.511, 1.27	0.006 $\mu\text{Ci}$ to 2 $\mu\text{Ci}$
$^{90}\text{Sr}$	29 yr.	$\beta^-$ , no $\gamma$	0.546 $\beta$ , 2.27 $\beta$ (from daughter $^{90}\text{Y}$ )	0.03 $\mu\text{Ci}$ to 5 mCi
$^{106}\text{Ru}$	368 days	$\beta^-$ , $\gamma$	3.54 $\beta$ (from daughter $^{106}\text{Rh}$ )	0.1 $\mu\text{Ci}$ to 100 $\mu\text{Ci}$
$^{207}\text{Bi}$	38 yr.	$\gamma$ , Internal Conversion Electron	0.570, 1.0648 $\gamma$ ; 0.976, 0.482 ICE	0.03 $\mu\text{Ci}$ to 2 $\mu\text{Ci}$
$^{241}\text{Am}$	432 yr.	$\alpha$ , $\gamma$	5.48 $\alpha$ ; 0.026, 0.060 $\gamma$ ; numerous Np X-rays	0.1 $\mu\text{Ci}$ to 10 mCi

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